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SECTION OF GEOLOGY AND MINERALOGY

APRIL 3, 1939

DOCTOR JOE PEOPLES, Wesleyan University, Middletown, Conn.: *The Stillwater Igneous Complex, Montana.* (This lecture was illustrated by lantern slides.)

A banded igneous complex of norite, gabbro, pyroxenite, peridotite, and related rocks is exposed for thirty miles along the northeastern margin of the Beartooth Range in Montana. This series of igneous rocks which has been called the Stillwater Complex from its magnificent exposure in the canyon of the Stillwater River is adjoined on the north by Paleozoic sedimentary rocks and on the south by pre-Cambrian granite and metamorphosed sediments. Evidence is presented that the igneous complex is a sheet or lopolith intrusive into pre-Cambrian sedimentary rocks and in turn intruded by pre-Cambrian granite; that the top of the complex was eroded before the deposition of the Middle Cambrian which rests unconformably on it; that during the Laramide orogeny the Stillwater Complex and overlying Paleozoic beds were tilted, and, in part of the area, turned on edge and thrust to the northeast along the Beartooth thrust fault.

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The Stillwater Complex consists of a number of rock types made up of a relatively few minerals which vary greatly in their relative proportions. The important primary minerals are plagioclase (labradorite and bytownite), diopside, orthopyroxene, olivine, and chromite. The arrangement of the rock types in stratiform layers is one of the most striking features of the complex. Within some of the layers, the platy minerals such as pyroxene and plagioclase are arranged with their two long axes in the plane of banding. This is a planar structure; no indication of linear structure was found.

The complex has been divided into four zones: (1) the Basal Zone of norite considered to be the chilled primary magma; (2) the Ultramafic Zone consisting of pyroxenite, harzburgite, and dunite; (3) the Banded Zone containing norite, anorthosite, anorthositic norite, and troctolite in stratiform layers; and (4) the Upper Zone of anorthosite, gabbro, norite, and related rocks.

Several columnar sections of the complex are compared and the various zones show the following thicknesses:

Upper Zone	800 to 6000 feet
Banded Zone	3700 to 7350 feet
Ultramafic Zone	1850 to 3300 feet
Basal Zone	0 to 200 feet

The East Boulder Plateau section of the complex has a thickness of over 16,000 feet.

The mineral deposits associated with the complex consist of chromite in the Ultramafic Zone, nickel-copper sulfides of the Sudbury type at the base in several places, and disseminated platinum at several horizons in the Banded and Upper Zones.

The Stillwater Complex shows remarkable similarity to the Bushveld Complex in rock types, mineral variations, primary structure, and associated mineral deposits. Reasons for believing in similarity of magma type, mode of intrusion, and origin of rock types are presented. The Stillwater Complex is also compared with other lopoliths such as the Duluth gabbro, Minnesota; the Sierra Leone lopolith, West Africa; the Bay of Islands lopolith, Newfoundland; and others.

The origin of the various rock types of the Stillwater Complex is believed to be the result of the differentiation in a lopolithic chamber of a magma approximating the composition of the basal norite. Possibly additions of magma were made as differentiation progressed. Movement of crystals under gravity is believed to have been the most important factor in development of the various rock types, but additional factors are needed to explain the banding and an intrusive dunite in the Ultramafic Zone.

SECTION OF BIOLOGY

JOINT MEETING WITH THE SECTION OF PHYSICS AND CHEMISTRY
APRIL 10, 1939

C. W. COATES, New York Aquarium, and RICHARD T. COX, New York University: *Observations on the Electrical Discharge of the Electric Eel.* (This lecture was illustrated by lantern slides and demonstration with the oscillograph.)

The electric eel, *Electrophorus electricus* (Linnaeus), is the largest of a number of electric fishes, none of which is related to each other. It has also the greatest electric power of any of these fishes.

It is native to the fresh waters of northern South America, ranging from the Amazon basin to the Orinoco basin. The largest recorded specimen exceeded eight feet in length and weighed sixty-six pounds.

The head and body of the fish do not exceed one-fifth of the total length and weight, the remaining four-fifths being tail, of which about two-thirds is electric tissue. The electric tissue is divided into three pairs of electric organs, the largest beginning immediately at the end of the body and running on either side with a nearly uniform cross-section to a point about equidistant between snout and end of tail where it begins to taper off. These organs are called the *large electric organs.* A second pair of organs start where the large electric organs begin to taper, lying about the large electric organs and enlarging at the expense of the first pair. These organs are called the *bundles of Sachs.* The third pair of organs is buried in the tissue at the base of the anal fin and reaches from the end of the body to the end of the tail. This pair is small in cross-section and is called the *organs of Hunter.*

The skin is naked and of somewhat complicated structure. It is from thirty to forty cells deep, and is interlaced with a number of cone-shaped prolongations of the corium extending at right angles to the surface of the body. These prolongations are tipped with palisade-like cells.

The discharge can be made at will, but the control of its intensity by the fish is restricted. There is a characteristic discharge of the bundles of Sachs which is always the same and which is known as the *minor discharge*. This organ can be discharged without the others. The electromotive force is of the order of forty volts. This discharge is given frequently while the fish is swimming. The large electric organs have also their characteristic discharge, known as the *major discharge*. Its electromotive force may attain five hundred volts in a mature eel. This is liberated in trains of from two to five discharges, following a minor discharge. The duration of a single discharge of either type is of the order of two one-thousandths of a second, and the common interval between successive major discharges in a train is of the order of a one-hundredth of a second.

There is sometimes observed a discharge of intermediate and irregular voltage occurring between a minor discharge and the following train of majors. The origin of this discharge is not altogether certain, but its power indicates that it must be a discharge of the large organs with some modification, perhaps produced by the simultaneous discharge of the organs of Hunter.

The major discharge is used to defend the eel against enemies and to immobilize its prey, which appears to be smaller fishes only.

Although the electric eels suffer no injury from other eels, they can detect the discharge of other eels at some distance and are attracted to the discharging fish, particularly to the anterior end which is always electrically positive.

The major discharge traverses the large electric organ as a pulse of potential gradient running from anterior to posterior with a speed of the order of a thousand meters a second. The discharge at each part of the organ is "triggered" by the nerve running from the spinal cord to that part. The fact that the speed of propagation is much higher than the speed observed in nerves suggests that the fish has a mechanism for

retarding the discharge of the anterior part until the pulse reaches the posterior part.

The discharge of the large electric organs through various electric circuits has been studied in some detail and analysis of the measurements made shows that the electric tissue of the organ can be schematically represented as a constant electromotive force and a variable internal resistance. The discharge is produced by the sudden lowering of this resistance from its high value when the organ is at rest to a value low enough to produce a current around one ampere on short circuit.

By gentle prodding, the eel can be stimulated into releasing a thousand discharges in about three minutes. The fatigue produced by these discharges shows itself by an increase, which may be as high as eight-fold, in the internal resistance of the tissue during discharge. This evidence of fatigue is almost the same whether the eel discharges on open circuit or through a low resistance, and seems, therefore, not to depend on the total quantity of electricity passed. Recuperation from this fatigue, as measured by the resistance, is almost complete within a few minutes after the stimulation has ceased. The tissue is rectifying, as shown by the fact that a battery of higher electromotive force than that of the organ, connected so as to oppose the discharge, does not reverse the direction of the current.

SECTION OF PSYCHOLOGY

April 17, 1939

Professor Harry L. Hollingworth, Columbia University: *Psycho-Dynamics of Chewing.*

Motor automatisms, collateral and incidental to some main occupation, are characteristic of the behavior of men and of the lower animals. Stamping, swaying, tapping, biting, chewing, are random examples. These are often said to be related to tension, either as signs of it or by way of expression or relief. Little experimental work has been done, and the present paper summarizes a detailed investigation, by experimental methods, on groups of human subjects, using automatic chewing as the automatism investigated. Control conditions, to match the use of the conventional masticatory, were provided by the use of mint wafers, giving the same sensory stimulation but unaccompanied by the motor activity. The results of the whole series emerge in a well articulated total pattern.

Study of the energy cost of sustained chewing, as reflected in pulse rate and in metabolism measures showed that this cost varied with the motor activity level in general. The more active the general level, the lower the added costs of the motor automatism. With vigorous activity the motor automatism is carried with no added energy cost, due to the reduction of random and restless movement which accompanied sustained mastication.

Muscular tension throughout the body is measurably reduced while chewing. This was shown in a variety of ways. Direct measures of tension in an unoccupied set of muscles, during active work, showed this reduction. Objective ratings, by trained observers, of the frequency of random restless movements showed these to decline in periods when the masticatory was in use. Subjective ratings, by the workers, of their felt strain and relaxation, during work periods, showed decreased feelings of strain and a general posture of relaxation during automatic chewing.

The rate of fluctuation of visual designs seen in equivocal perspective was found to increase. This is the opposite of the alleged effect of fatigue on this index, and more closely resembles the effect of tea, coffee, and similar "refreshing" agents, as reported in the literature.

Measurement of the energy put into the working muscles of the main occupation, while chewing, showed a distinct and measurable increase. Writing pressure (point pressure) increases while chewing is engaged in, and in a specially designed pin target test, arm thrusts were made more vigorously during the periods of automatic chewing. The motor automatism is thus "dynamogenic," in the sense that, by acting as an overflow for motor restlessness it conserves energy. The surplus thus saved may be unwittingly discharged into the channels engaged with the main occupation.

Speed in typing was found to increase while chewing. With one subject this increase was at the expense of accuracy. The other typist made notable speed gain with correlated improvement in accuracy. In spite of this increased speed, both typists reported to have proceeded with reduced tension. There are apparently individual idiosyncrasies here as elsewhere, and sustained mastication does not affect all workers in the same way.

Marked individual differences were found in the characteristic muscular tension with which individuals worked. The workers on a higher level of tension, in general, experienced the greater relaxation when the motor automatism was introduced. Different degrees of tension were also found to be consistently characteristic of different types of intellectual and motor work.

Out-put studies were made on nine different kinds of work. No evidence was found that sustained chewing (controlled for sensory stimulation and like factors) interfered with out-put. There was some indication of an adverse effect on work involving new learning, with facilitation in the case of simple repetitive activities, but the data are inadequate on this point.

The interpretation of these results offered is a simple one. It involves no specific neurological hypotheses, although the results may also be explained by various current theories of neuro-muscular dynamics. The primary role of chewing is in the mastication of food. Eating is ordinarily a quiet and relaxing occupation, with random restlessness at a low point. While eating we sit; we relax; and the general feeling tone is one of agreeableness and ease.

An important item of the eating situation is chewing. We suggest that, as a result of this contextual inclusion, chewing, as a "conditioned stimulus," brings with it, whenever it is sustained, a posture of relaxation.

Chewing, in other words, serves as a reduced cue, and to some degree redintegrates the relaxation of meal time. The remaining parts of the picture follow from this redintegrated posture of relaxation. The motor automatism, then, does provide relief from tension, and the tension that is thus relieved is muscular. As the result of this tension reduction, on an activity level higher than that of a basal resting state, the motor automatism is carried at little or no energy cost, and surplus energy is rendered available for the main occupation. The same or improved out-put is achieved with a subjective relaxation that is also objectively identifiable.

SECTION OF ANTHROPOLOGY

April 24, 1939

Professor Ralph Linton, Columbia University: *Culture Sequences in Madagascar.*

The great island of Madagascar presents a puzzle to ethnologists. In spite of its close proximity to the African mainland its inhabitants all speak languages of the Malayo-Polynesian stock and possess many elements of Indonesian culture. Physically the population shows a mixture of Negroid and Indonesian characteristics but with considerable local differentiation. Predominantly Negroid groups occupy the coastal lowlands; predominantly Indonesian ones the high interior plateau. It has usually been assumed that the aboriginal population was made up of Negroes who were conquered and partially displaced by a relatively late invasion of Malays but native traditions and the geographic distribution of cultures and physical types indicates that this is, at best, an oversimplification.

Tribes living in the dense rain forests of the eastern slope of the island give evidence in both their traditions and physical type of the presence here of Negritos who, both physically and culturally, resembled those of Indonesia rather than Africa. These Negritos may have been the true aborigines.

At a later time the island seems to have been invaded and largely occupied by a brown-skinned, wavy-haired group with a rather simple culture reminiscent of that of the more primitive tribes of Indonesia. These people were ignorant of weaving, dressing in mats and bark-cloth, made no pottery and had neither the shield nor the bow. However, they practiced agriculture, including the raising of taro, yams and unirrigated rice, and had some knowledge of iron working. These people unquestionably were of Indonesian origin, but their culture suggests that they left that region before it was affected by Hindu civilization.

A second wave of Indonesian migrants appear to have come to Madagascar from Sumatra shortly after the beginning of the Christian era. These people brought with them such culture elements as warp dyed weaving and irrigated rice culture. According to the traditions of their descendants they landed first on the southwest coast of the island, but rapidly forced their way into the central plateau, where they established themselves as an aristocracy among the older Indonesian population.

The Negroid tribes of Madagascar do not agree in their physical type with the inhabitants of the adjoining mainland. They resemble much more closely the peoples of far northeastern Africa. It is impossible to say whether their ancestors arrived before or after the Sumatran immigrants but they certainly arrived after the people of simple Indonesian culture and expelled them from the lowlands. In this expulsion they may have been aided by malaria, for the Indonesian population is highly susceptible to this disease while the Negroids are resistant to it. At the beginning of the historic period the Indonesians occupied the malaria-free parts of the island, the Negroids the malarial parts. This condition is closely parallel to that in Melanesia where the occasional groups of brown-skinned, wavy-haired people are limited to small malaria-free islands.

The route by which the various Indonesian settlers reached Madagascar must remain problematical for the present but it seems fairly certain that they did not sail directly across the Indian Ocean. If they had done so they would almost certainly have discovered and colonized various islands there which were unoccupied when first visited by Europeans. It seems more probable that they crossed well to the north and reached Madagascar by following the African coast southward. If such was the case, the African natives must have been subject to considerable early contact with Indonesian culture and this possibility should be considered in all attempts to reconstruct African origins.

NEW MEMBERS

Elected April 3, 1939

SUSTAINING MEMBERS

Clarke, Hans T., D.Sc., Professor, Biological Chemistry, Columbia University, New York, N. Y.

Peck, Samuel M., M.D., New York, N. Y.

Zellers, John A., Vice-President, Remington Rand, Inc., New York, N. Y.

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Allen, Alexander Aloysius, M.A., D.D.S., Instructor, Chemistry, New York University, New York, N. Y.

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Becker, Marie F., New York, N. Y.

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Butler, Rear Admiral Charles St. John, M.D., U. S. Navy Dept., Washington, D. C.

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